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Brown-rot and Related Diseases of Stone Fruits in Oregon

By

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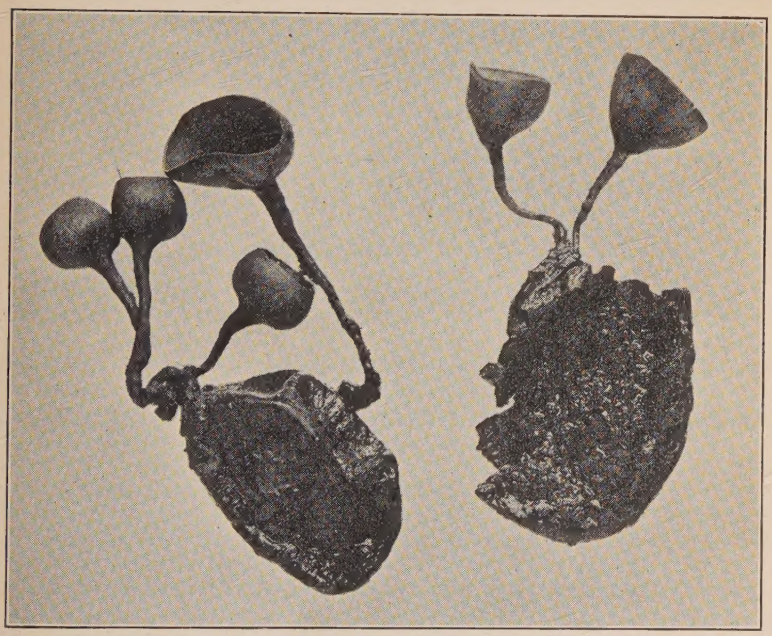

Fig. 1. Brown-rot spore-cups arising from buried prune mummies at blossom time. The principal source from which the disease starts in the spring. Early plowing and frequent cultivation through the blooming period are the most effective means of preventing their development.

CORVALLIS, OREGON

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Brown-rot and Related Diseases of Stone Fruits in Oregon

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INTRODUCTION

Brown-rot losses. The brown-rot problem in the humid sections of Oregon demands serious consideration. The total damage caused by this disease in an epidemic year is appalling. In 1923, for example, not less than twenty-five percent of the entire prune crop in Western Oregon was destroyed; in some orchards the loss exceeded fifty percent. In sweet cherry orchards in bad years a large amount of fruit is ruined. The peach crop likewise suffers severe damage in some years. Not only is the loss on the tree serious, but much loss results from the development of brown-rot after the fruit leaves the orchard.

Indirect effects. While the direct effects are serious enough, one cannot overlook the indirect depressing effects on future demand which are bound to follow not only from fresh fruit reaching the market with brown-rot present but also from the presence of brown-rot in such a commodity as dried prunes. A prune, even though only slightly attacked when dried, is unpalatable and undesirable from the consumer's point of view. A reduced demand following bad brown-rot seasons is a natural result unless growers or packers are successful in keeping such affected fruit out of the finished product.

Variability of the disease affects control problem. How to lessen the chances of severe brown-rot outbreaks without going to unnecessary expense is not altogether a simple problem for the Oregon orchardist. If conditions were favorable to the disease every year, and if orchards in all localities were equally subject to attack, growers generally would find it necessary and profitable to employ a regular, systematic, annual spraying program beginning in the spring and continuing through the season just as eastern peach growers are obliged to do. In this state, however, brown-rot is not a serious problem every year. It is only once in four or five years, perhaps, that the disease is widely and disastrously prevalent, although occasionally several bad years may come in succession. Furthermore, localities within the state differ greatly from each other with reference to the severity of the disease. Even in a single orchard certain sections may be so situated as to provide especially favorable conditions for brown-rot development, while other sections may regularly enjoy comparative freedom from attack. Since these things are so, it is clearly impossible to set down a uniform and invariable brown-rot control program which will be satisfactory in all sections of Oregon and in all years.

It has, nevertheless, been demonstrated both experimentally and in actual practice that, by adapting well-established control measures to fit the individual orchard and the particular season, Oregon fruit growers can bring about a large reduction in brown-rot losses. In very many

localities preventive measures deserve general adoption. They constitute a safeguard or insurance against an ever-present danger. In some years, it is true, there may be only small returns on the investment, but epidemic years are bound to come and when they do come it is only through such precautions that many growers can escape overwhelming loss.

In order to put into operation an effective campaign against brown-rot, it is necessary for the grower to have a correct understanding of the nature of the disease, of the climatic and local conditions that affect its development, and of the stages or periods when efforts at prevention will get the best results. Armed with this essential information, and guided by his experience and judgment, the grower can adopt a control program suited to his own particular situation.

THE NATURE OF BROWN-ROT AND RELATED TROUBLES

False brown-rot or internal browning. Since true brown-rot causes a brown decay of the flesh of infected fruits, growers of stone fruits have been inclined to give the name "brown-rot" to any condition of the fruit where there is brown discoloration. This is often incorrect. For example, in some years, as prunes approach maturity, large losses are experienced from an internal breaking down of the flesh, accompanied by brown discoloration and disagreeable odor and taste. This condition, though often mistaken for brown-rot, has an entirely different cause. True brown-rot infections start at the surface; this internal browning usually starts immediately around the pit and often extends outward until in some cases it reaches the skin and involves the whole flesh. The trouble is not due to a parasitic fungus or bacterium and is not infectious. It seems to be the result of a lack of balance between the evaporation rate and the rate of water intake by the tree or to originate from some other sort of nutritional disturbance connected with climatic or soil conditions that have been unfavorable to normal ripening. The prune grower has little chance to defend himself against this trouble except as he derives some aid by conserving soil moisture and maintaining the best possible nutritional balance by good horticultural practices.

Two related disease-producing fungi. The true brown-rot disease which is so widespread in the United States is caused by a fungus usually designated by the scientific name *Sclerotinia cinerea* (Bon.) Wor. It is this ordinary brown-rot fungus that causes the severe attacks of fruit rot of stone fruits in Oregon. It often causes blossom blight as well. There is, in addition, a closely related fungus common on the Pacific Coast which often causes very severe attacks of blossom and spur blight and twig cankers on all kinds of stone fruits and on certain varieties of pears,* but which causes little rotting of fruit. This fungus was investigated several years ago by G. B. Posey at the Oregon Experiment Station. His findings are reported in an unpublished thesis. The complete life-history of this parasite is not yet known. In tests it failed to produce the apothecial (spore-cup) stage under conditions that gave abundant development of this stage with the ordinary brown-rot fungus. It produces

* H. S. Jackson. Pear canker. Ore. Exp. Sta. Second Bien. Crop Pest and Hort. Rep. pp. 271-272 (Jan. 15, 1915).

spores in chains very closely resembling those of ordinary brown-rot, but it differs from the latter in the appearance and manner of spore production on the host plant. In artificial cultures it has also proved to be very different from the common brown-rot fungus or other described species. (See Fig. 2.) We have, therefore, considered it a new species and have assigned to it the name *Monilia oregonensis* Barss and Posey.* The disease caused by it will be referred to as Monilia blight to distinguish it from the true brown-rot disease.

Blossom and spur blight. The moist and cool weather of early spring is often very favorable to the infection of blossoms by the spores

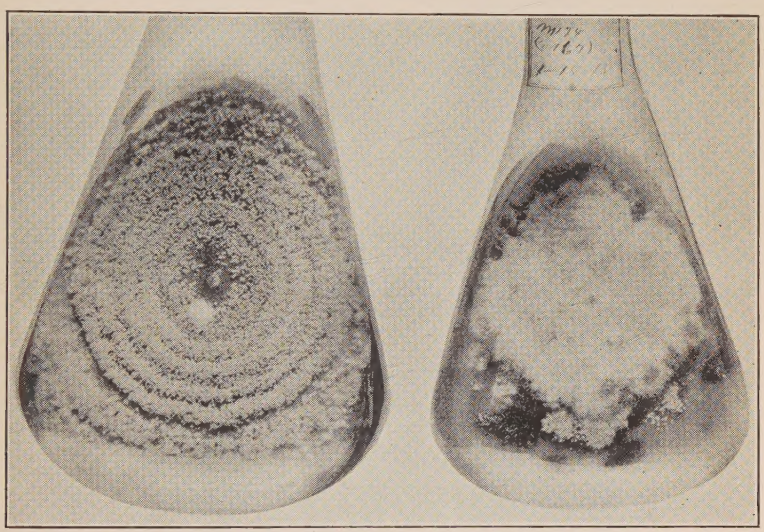

Fig. 2. Month-old cultures on prune agar of the common brown-rot fungus (on the left) and the typical new Monilia blight fungus (*Monilia oregonensis* Barss and Posey), on the right. Note the abundant production of spores in concentric rings in the one and the absence of this in the other. Both fungi isolated from cherry.

of the Monilia blight fungus and also to some extent by the spores of the ordinary brown-rot fungus. The method of attack and the effects are similar with both fungi except that the Monilia blight appears to work more rapidly and progress farther than the brown-rot fungus. Petals or calyx lobes and likewise the stigmas of the flower are very subject to infection. The first sign is a small brown spot on the petal, calyx lobe, or tip of the pistil. This discoloration spreads rapidly if the weather continues moist. The disease eventually kills the parts attacked and begins to invade the base of the flower, which then turns dark. After the flower has been killed the fungus often works down the flower stalk to the spur on which it was borne. The spur is frequently killed with all its blossoms and leaves as shown in Figs. 3, 4, and 5, and the disease may even extend to the twig, causing a small canker as shown in Fig. 5. If the twig is small the canker may girdle it, resulting in the death of

* Formal description submitted for publication in Phytopathology.

the parts beyond. If the weather continues moist for several days after infection has taken place, spores often appear in delicate grayish tufts which give the dead flower parts a velvety appearance. If the atmosphere is too dry, however, the Monilia spores may not appear till the following winter and spring. As a rule, shortly after the blossoming period the advance of the blight is checked so that the cankers under average

Fig. 3. Blossom and spur blight on prune, at times a cause of serious losses. Best controlled by a pre-blossom spray.

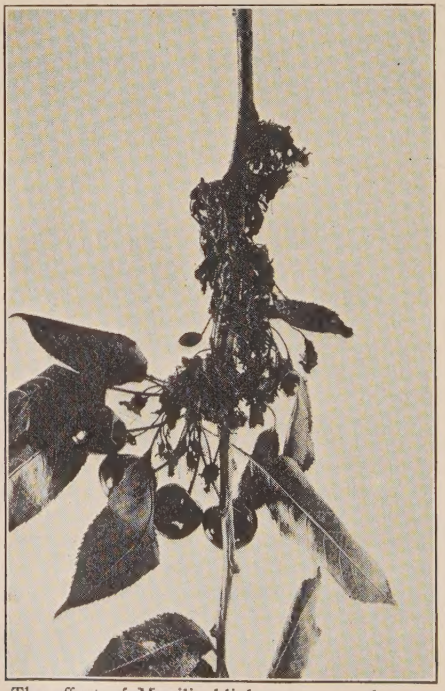

Fig. 4. The effect of Monilia blight on sweet cherry. At least four out of five blossom clusters on this branch were killed.

Oregon conditions rarely reach large extent. The black blighted blossoms and leaves shrivel, and remain hanging to the dead spurs throughout the following winter.

The amount of loss resulting from Monilia blight and brown-rot attack on the blossoms in Oregon varies greatly not only with the locality and the season but with the variety of fruit. Apricots are

Fig. 5. Prune blossoms ready to open. The shriveled, black spur on the left-hand twig which was killed by Monilia blight the year before is now bearing cushions of spores (X) ready to scatter and attack the open flowers. When pruning, such dead twigs should be removed and destroyed as far as practicable.

exceedingly susceptible to attack in moist localities. Old trees have been observed which have not been known to set a single fruit for years because of the blight which regularly killed every blossom. The set of fruit in prunes and plums is often severely damaged. Sweet cherries suffer to an important extent in some years. The Winter Nelis pear has been reported as subject to Monilia blight attack and pear trees of unknown variety have been found which suffered year after year complete loss of set from the disease. Most commercial varieties of pears grown in Oregon, however, do not appear to be susceptible to this fungus although other types of blossom and spur blight sometimes cause considerable loss. In Western Oregon as a whole there is probably much more damage resulting from Monilia blight or brown-rot attack on blossoms than growers realize. The effects of these early spring attacks are frequently attributed to the results of cold, wet weather or to frost and thus pass unrecognized.

The only way the Monilia blight fungus lives over winter, so far as now known, is in the dead twigs and flower parts and the occasional

mummied fruits that were attacked the previous year. If these parts are examined closely in late winter or early spring one will find developing on them little compact gray cushions of spores scattered here and

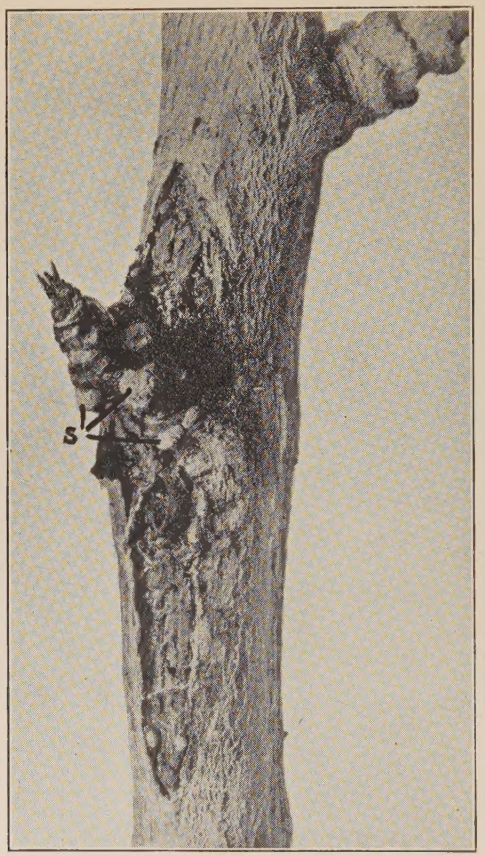

Fig. 6. Dead spur and twig canker caused by *Monilia oregonensis* Barss and Posey. Enlarged to show the sporodochia (spore cushions) formed the following winter. S = typical sporodochia. Spraying just before bloom helps to destroy these sources of infection.

there (see Figs. 5 and 6). Examined under the microscope each velvety mass is seen to consist of hundreds of thousands of spores. It is these spores, caught by the breezes, carried by insects, or washed by the rain, that bring about the blossom infections in the spring. A thorough spray applied just before the blossoms open will do much to kill the spore tufts and protect the bloom, while the systematic removal of dead spurs and mummies where possible is a direct blow against these sources of infection.

Fruit rot. It is the ordinary brown-rot fungus which causes practically all of the rotting of fruit from which our orchards of stone fruits suffer. Infections may take place at any time during the season, but the

disease works more rapidly as the fruit approaches maturity. After the spores of the disease are carried to the fruit they must have moisture in order to germinate and cause infection. If, after spore germination has begun, the moisture disappears too soon, the fungus may perish without producing infection. The surface of the fruit must be wet for several hours before the infection thread can penetrate, but, once it enters, the

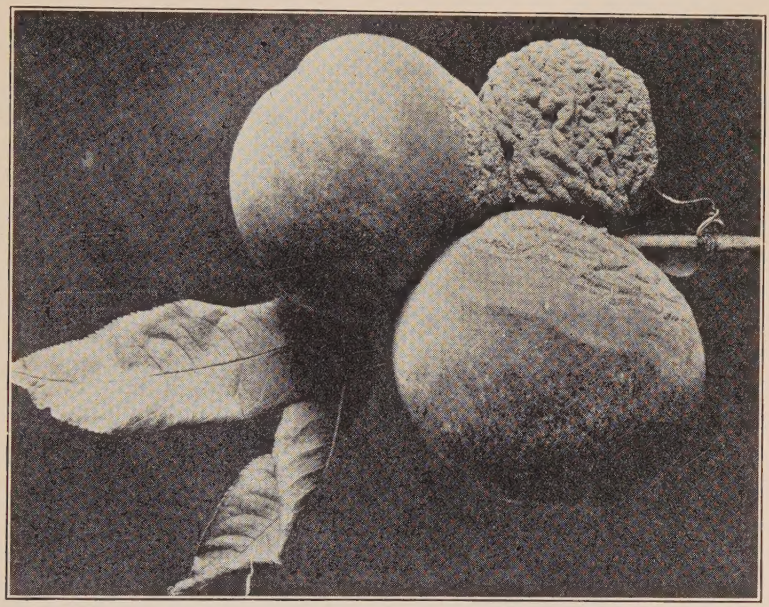

Fig. 7. Brown-rot attack on a ripening cluster of peaches. Myriads of powdery gray spores are being produced ready to spread the infection everywhere.

fungus continues to develop in the flesh until the whole fruit is rotted. Where the skin of the fruit is broken by injury of any kind, spores entering the wound are of course apt to cause infection without regard to surface moisture. The fungus can also spread from one decaying fruit to another in contact with it even in dry weather. As a result, where one fruit in a cluster becomes infected, the whole cluster usually decays, as shown in Fig. 7.

The first visible sign of infection is a very small round brown spot on the surface of the fruit. This spot gradually enlarges until the whole fruit is involved. The flesh turns brown and becomes soft. The diseased fruit frequently falls to the ground, but oftentimes, especially as the fruit ripens, it may remain hanging on the tree, where it gradually shrivels into a "mummy." A growth of spores usually appears on the surface of diseased fruit often in more or less distinct, concentric circles of velvety gray tufts, which turn powdery as the millions of spores are set free. These spores are scattered like dust in the air and in wet weather cause a very rapid spread of the disease. Whether hanging in the tree or resting on the ground every spore-covered fruit is a menace which cannot be overlooked.

The manner in which the brown-rot fungus lives over from one season to the next is very interesting. It is important that the fruit-grower should have a correct understanding of this part in the life cycle of the disease. When a brown rotted fruit falls to the ground it gradually becomes transformed into a mummy in which the fungus may remain alive but dormant for a long time. Even when buried through cultivation it does not die. In the usual course of events, after two winters have passed, these mummies put forth delicate outgrowths or stalks at the tip of which the small brown, cup-like, fruiting bodies (apothecia) of the fungus are formed (see Figs. 1, 8, and 9). When not too deeply buried beneath the soil, the mummies send the stalks up to the surface, sometimes a distance of several inches, so that the cups always lie free on top of the ground. Here they discharge their myriads of spores into the air currents, which carry them up into the tree tops. These spore-cups appear just about blossoming time. From them come the majority of early infections that give the disease its first start in the season. Old mummies hanging on the trees from the year before may also produce a crop of spores in early spring (see Fig. 10). It stands to reason, then, that any practices which can be employed to remove mummies from the orchard or to prevent the forming of the spore cups in the spring will help to prevent early outbreaks

Fig. 8. Spore-cups of common brown-rot attached to mummied cherries. Natural size.

Fig. 9. Brown-rot spore-cups on the surface of the ground viewed from above. The mummies from which they spring are buried in the ground. Natural size.

and in this way reduce the danger of serious attacks later. It should be borne in mind in this connection that the rotted fruit that falls to the ground at any particular harvest period does not as a rule produce a crop of spore-cups until the second spring afterward.

Brown-rot and dried prunes. Two questions have often arisen among growers and packers of prunes: (1) Is the brown-rot fungus killed by the process of drying? (2) Can it attack and develop anew on prunes which are exposed to living spores after drying has been completed? These questions are answered conclusively in the negative by investigations conducted in 1913 by G. H. Godfrey* at the Oregon Experiment Station and confirmed in 1923 by the writer. Godfrey showed that the common method of drying killed the brown-rot fungus without fail. In fact a temperature of 130° F. for any length of time will kill it. All attempts to grow the fungus on dried prunes have proved unsuccessful.

Fig. 10. A cluster of last year's mummied prunes hanging in the tree and covered with a new growth of spores. Such sources of infection should be taken out of the orchard at pruning time and destroyed.

NATURAL CONDITIONS PROMOTING OR RETARDING BROWN-ROT

Wet weather. When brown-rot spores are present, abundant moisture for a number of hours continuously is necessary to permit infections. Wet conditions are favorable not only to infections but also to an abundant production of spores on the surface of diseased fruit or blighted blossoms and spurs. Every period during the growing season, therefore, when protracted rains, mists, or fogs keep the trees constantly wet for any considerable length of time is a danger period likely to be followed both by more rot and by increased seeding down of the orchard by spores.

Warm weather. In general, warm temperatures favor the development of brown-rot in the fruit tissues so that when warm weather is combined with wet weather for a few days the disease is likely to make very rapid progress. If not checked in a very short time, a destructive epidemic may occur.

Dry weather. Dry weather always hinders or prevents both spore development and spore germination. It is the greatest natural agency for brown-rot control. Winds likewise make conditions unfavorable for infections by helping to dry up moisture in the trees. Orchards on

* Ore. Exp. Sta. 2nd Bien. Crop Pest and Hort. Rep. (1915) pp. 276-277.

breezy hill slopes are often found to suffer very little from brown-rot even when surrounding orchards are badly affected. East of the Cascade Mountains the weather during the growing season is usually so dry from start to finish that brown-rot has little chance to develop. It is largely on this account that Eastern Oregon cherries, peaches, and prunes are in such demand in fresh fruit markets. They seldom go down with brown-rot in shipment or on the fruit stands. As a general rule in arid sections brown-rot causes little or no damage and usually requires no attention.

Location. The lay of the land often has a good deal to do with the severity of brown-rot in an orchard. Low-lying and sheltered spots, plantings surrounded by timber, or locations near bodies of water, are favorable to the disease on account of the greater humidity of the air or the lack of rapid air movement, which factors tend to retard the drying off of moist surfaces and favor infection. There are also in Western Oregon localized areas where rains are exceptionally frequent and persistent. There are likewise localities that are unusually subject to fogs. In such situations growers have to use extraordinary precautions to hold brown-rot in check.

Maturity of fruit. As a general rule brown-rot attacks develop with the greatest rapidity as the fruit ripens. Not only is the fruit more susceptible to infection at this stage, but the fungus works faster within the tissues and sporulates more abundantly. When mature fruit cracks open in rainy spells, added opportunity is given for brown-rot to take hold. By the time prunes are ripe, moist weather and fogs are rather to be expected in Western Oregon. As a consequence pre-harvest spraying is exceedingly valuable.

Insect injuries. Stone fruits in Oregon are subject to injuries from biting insects like the Syneta beetle, the larvae of the bud-moth and peach and prune twig miner, the young of the tree-cricket, adult yellow-jackets, etc. Brown-rot spores often germinate on the moist tissues exposed by their bites and infections may result. When such insect attacks are abundant the problem presented is often a perplexing one, especially since brown-rot may thus be perpetuated in an orchard in spite of prolonged dry weather. The use of arsenical sprays in connection with some of the brown-rot sprays might often prove worth while in reducing the number of fruit-feeding insects.

Dense foliage. It is self-evident that the denser the foliage in a tree the more slowly will the interior of the tree dry off after a wet period and the more favorable will be conditions for brown-rot. Prune trees tend, if neglected, to develop a dense outer canopy of leaves, with the fruit for the most part borne just beneath this protecting foliage. Such a condition not only favors infection but hinders effective spraying. Open tops produced by proper pruning do not have these defects. They also encourage a better distribution of the fruit.

CONTROL MEASURES

Experimental work. The general principles of brown-rot control have been developed as a result of many years of toil by plant pathologists connected with various state experiment stations and the United States Department of Agriculture. In order to work out the application of these principles to the conditions which exist in the Pacific Northwest, investigations were conducted in Western Oregon by the Oregon Experiment Station from 1913 to 1917, and in both Western Oregon and Western Washington by the Office of Fruit Disease Investigations, United States Department of Agriculture, from 1915 to 1919.* The results of the numerous tests conducted by both agencies are in agreement and point to the very great value of protective measures against brown-rot in our humid sections. In the discussion which follows, information secured from these experiments has been used as a basis for recommendations. Thanks are due to Dr. Charles Brooks and D. F. Fisher, the Federal investigators, for their constant cooperation with the workers of the Oregon Experiment Station and for their kindness in permitting the use of their results to supplement those of the Oregon workers in constructing a program of control.

Local conditions important. As already intimated, local conditions play a dominant part in the problem of control. Each grower will have to bear this in mind in deciding on what program for brown-rot prevention to carry out. In some sections, in order to insure reasonable safety against serious losses, the growers should apply several thorough sprayings each year in addition to other preventive measures. In other sections, as for example in Eastern Oregon, the chances of brown-rot damage are so remote that except under extraordinary conditions it would be a useless waste of time and money to put on even a single spray for brown-rot during the season.

Patrolling the orchard. Because of this situation, each grower must know not only the facts about the brown-rot in general but also the facts about brown-rot in his own orchard and neighborhood. Many orchard owners are now accustomed to paying little attention to the disease until it has reached serious proportions and control measures are of no avail. It is a great advantage for the grower to go through the orchard at regular intervals for the particular purpose of observing the extent of infection. Continued from year to year, this practice will enable him to judge, as he could in no other way, just what the effects of weather and other factors are on his own place with respect both to blossom blight and to brown-rot development and thus help him to direct his control program intelligently.

Pruning. During pruning attention should be given to the removal and destruction of all mummied fruit hanging on the trees and as far as practicable of all blighted spurs and twigs in order to get rid of these sources of infection. Where trees are not open headed but dense, they should be pruned by thinning out rather than heading back. This puts the trees into the best shape for effective spraying. In addition, the better air circulation and the penetration of sunlight into the interior

* Brooks, Charles, and Fisher, D. F. Brown Rot of Prunes and Cherries in the Pacific Northwest. U. S. Dept. of Agric. Bul. 368. March 6, 1916.
———— ————, Transportation Rots of Stone Fruits as Influenced by Orchard Spraying. Jour. Agr. Res. 22:467-477, Nov. 26, 1921.

of the tree will aid quick evaporation of moisture from fruit and foliage and thus hinder infection.

Early cultivation. By plowing the orchard in the fall, winter, or early spring and by frequent harrowings during the entire blossoming period, the orchardist can do much to interfere with the development and activity of the delicate spore cups which grow up at that time from the old mummied fruits in the soil. This greatly reduces the sources of early brown-rot infections and is a practice that should be followed wherever orchard soil conditions permit.

Spraying. In many sections spraying is absolutely necessary to insure against the chance of serious brown-rot attacks when favorable weather conditions arrive. Where blossom and spur blight is prevalent one spray should regularly be applied just before the blossoms burst. This helps to sterilize the spore clusters on old blighted parts and gives a protective coating to the unfolding buds. Marked benefit from this application has been recorded in Experiment Station and Government tests the results of which have been substantiated by the experience of growers. As soon as the petals have dropped, and again when the shucks have fallen from the fruit, spray applications are often desirable to protect the young fruit against early infections. As warm weather comes on, occasional rainy periods may give new impetus to the disease. Summer sprays should therefore be applied whenever experience and orchard observations seem to justify them. In the five years' tests conducted by the Oregon Experiment Station in different sections of Western Oregon and in similar tests by Federal investigators, the most effective single spray application of the entire season has almost without exception proved to be that which is given about a month before harvest. It is a protection against attack at the most susceptible period for the fruit and is important for all stone fruits in any section where brown-rot is a real danger. Thoroughness in spraying is essential to success. A fine mist spray with plenty of power back of it will give the best results.

Summer sanitation. Sanitation is the removal of sources of disease. The importance of summer sanitation in the peach or prune orchard can best be appreciated by considering the menace which exists where rotting fruit clusters hang in the trees, producing day by day enormous numbers of spores each capable of infecting a healthy fruit when given proper conditions. With this danger in mind, a few growers have made it a practice to patrol the orchard during the summer, examining each tree and knocking out all brown-rot clusters with a long pole provided at the top with a hook. This decayed fruit and any that may have dropped of its own accord is collected and destroyed.

Fall sanitation. Fall sanitation is carried on with the idea of getting rid of fallen and rotted fruit in order that such fruit may not develop into mummies and produce a crop of spore-cups later on. A few prune growers have made a practice of raking up and removing all fallen fruit from the orchard just ahead of the pickers, claiming that the practice pays for itself in the time saved by the pickers beside helping in brown-rot control. Other growers turn hogs into the orchard after picking is over and let them clean up the rotted fruit. Sheep have been tried but reports of injury to these animals from the swallowing of the pits argue against the practice.

MATERIALS FOR USE IN CONTROL APPLICATIONS

There are a number of different spray materials that are effective in the control of brown-rot and Monilia blight. The following discussion of the principal sprays in common use is offered in order that the grower may better understand the advantages and disadvantages of each.

Lime-sulfur. Ordinary lime-sulfur, either the usual liquid form or the commercial dry lime-sulfur, while effective against brown-rot, is dangerous in warm weather since it may cause severe injury to foliage or fruit often with much fruit drop. It is not safe to use on stone fruits except in the very early spring when cool weather is the rule. It is dangerous on peach foliage at any time.

Bordeaux mixture. This material is very effective against Monilia blight and brown-rot, especially in cool weather. Used in the 4-4-50 strength it has not caused injury on prunes at any period in the season in twelve orchard experiments carried on by the Oregon Experiment Station on prunes over a period of five years. Brooks and Fisher report, however, that in their experiments in the Northwest bordeaux has occasionally caused considerable foliage injury at times on both prunes and sweet cherries following rainy periods. It is known to be dangerous for peach foliage. Brooks and Fisher also report some size reduction in sweet cherries sprayed with bordeaux. As a protection against brown-rot during warm and comparatively dry weather bordeaux mixture does not appear to be quite as effective as sulfur-containing sprays or dusts.

Self-boiled lime-sulfur. This material was developed a number of years ago for the control of brown-rot on peaches in the Eastern United States. It has proved very satisfactory in Oregon, resulting in excellent control with no spray injury when properly made. It is rather disagreeable to make, however, and at times there is some danger of over-cooking, which may result in enough causticity to produce severe foliage injury. Substitute materials are now being developed which, like "dry-mix sulfur-lime," seem to have practically the same effective qualities without the drawbacks of the original. Brooks and Fisher report that self-boiled lime-sulfur has caused serious dwarfing of sweet cherry fruit in some of their experiments and hence advise against its use in cherry orchards.

"Wettable" or "dry-mixed" and colloidal sulfur sprays. Within recent years efforts have been made to find ways by which ordinary sulfur dust could be made to mix readily with water and serve as a spray. Several commercial sulfur pastes have been devised and put on the market. Atomic Sulfur is one of these. It has been used for brown-rot control with excellent results in Oregon and in many other parts of the country.

Within the last three years a very promising type of "wettable" sulfur has been developed which can be readily prepared by growers.* It appears to be a very good substitute for the old self-boiled lime-sulfur and is much less trouble to make. It consists of a dry mixture of sulfur, hydrated lime, and calcium caseinate. The proportions of the ingredients have not yet been entirely standardized, but the following formula has given excellent results against brown-rot in Eastern trials:

* Farley, A. J. Dry-Mix Sulfur Lime. N. J. Exp. Sta. Bul. 379. Feb. 1, 1923.

superfine dusting sulfur, 8 pounds; hydrated lime, 4 pounds; calcium caseinate spreader, one-half pound. These are thoroughly combined in dry form. The dry mixture can be prepared in advance of the spraying season and stored until the grower is ready to spray, when the powder is mixed slowly with water until it forms a thin paste. This is run through a strainer into the partly full spray tank; 12½ lbs. (the amount indicated in the formula) will be sufficient for 50 gallons of spray. This material spreads and adheres exceptionally well. The apparent merits of the material justify its trial in the Northwest. No spray injury has been reported from its use, but until it is tried on sweet cherries one cannot know whether there is danger of dwarfing with this fruit.

Recent investigations* on the fungicidal activity of sulfur have awakened an interest in colloidal forms of sulfur for fungicidal purposes. Certain types of colloidal sulfur appear to have greater efficiency in weak dilutions than do other types of sulfur suspensions. Further experimental work with such material is desirable before general adoption can be advocated.

Spreaders. The spreading and adhesive quality of many of the common spray materials may be greatly improved by the addition of some substance like soap, saponin, or casein. In fact it is impossible to secure satisfactory covering of smooth or waxy fruits like cherries or prunes without the use of a spreader. In the experiments conducted a few years ago by the Oregon Experiment Station and by the Federal Government in the Northwest, rosin fish-oil soap, either commercial or home-made, proved the best sticker and spreader of any tested. No soap spreader can be used with ordinary lime-sulfur, however. In the last few years the merits of casein as a spreader have resulted in casein spreaders largely superseding spreaders of the soap type. Commercial preparations of calcium caseinate are now available in all fruit sections. In some cases growers have encountered trouble in using powdered casein spreader with bordeaux and other fungicidal sprays due to the formation of gummy masses in the spray tank. Perhaps this is in part the result of adding the powder too fast to the tank. At any rate, such difficulty may be avoided by dissolving the spreader separately in a quantity of water before adding to the tank. Where a commercial spray material already contains casein, additional spreader is, of course, unnecessary.

Dusting with sulfur. In recent years improved dusting materials and machinery have resulted in a gradual increase in the use of dusting in some orchard sections in the Eastern States. Fruit growers in the Pacific Northwest have hesitated to take up this method since for most orchard diseases spraying has in general given more reliable protection. Dusts have been tested out, however, for brown-rot prevention in the Northwest, principally by the Federal Government. These tests are of interest since they indicate that, at least during warm weather, dusts containing sulfur as the active constituent are very satisfactory for the control of brown-rot on both cherries and prunes. No foliage or fruit injury has been noted and in the tests with sweet cherries no reduction of fruit size occurred. Sulfur dust is now used extensively in the East

* Young, H. C. The Toxic Property of Sulfur. Ann. Mo. Bot. Gard. 9:403-435, Nov. 1922.

for peach brown-rot control and recent tests by growers near Salem on peaches showed excellent results.

For the early spring applications, when the weather is almost invariably cool and hence unfavorable to effective action from sulfur in the elemental form, it is doubtful whether dusting will prove to be a satisfactory substitute for spraying, particularly against blossom blight. For summer applications, however, the dusting method is considered worthy of further trial by Oregon orchardists.

Coarse sulfur flour or coarse flowers of sulfur will neither cover nor adhere as well as the special dusting sulfur. Dusting sulfur is usually diluted with a small amount of some other material which prevents caking and helps it to flow freely. Lead arsenate dust is excellent for this purpose, but on account of its cost it is not advised except where the grower wishes also to secure control of some insect pest for which this material is a suitable poison. Hydrated lime is the diluent most commonly employed.

SUMMARIZED CONTROL PROGRAM FOR BROWN-ROT

The program here given represents the control measures advocated for Oregon orchards where experience shows brown-rot to be a persistent source of losses. In sections where brown-rot causes only occasional damage, the program may be modified to meet local conditions.

Winter pruning. Remove all mummied fruit and dead spurs and twigs. Prune for an open tree to facilitate spraying and hinder infections.

Early cultivation. Plow before the blossoms are ready to open and harrow the orchard repeatedly through the entire blossoming period to prevent as far as possible the formation and maturing of the brown-rot spore-cups from mummies in the ground where soil conditions permit.

Spray applications.

1. *Pre-blossom spray.* Bordeaux 4-4-50 (or lime-sulfur 1 to 50*), just before the blossoms open, when petals are showing white, to protect against blossom blight.

2. *Petal-fall spray.* Bordeaux 4-4-50, lime-sulfur 1 to 50,* self-boiled lime-sulfur 8-8-50, or a reliable substitute (dry-mixed sulfur and lime, Atomic Sulfur, etc.). When petals are gone. Desirable where blossom blight is abundant.

3. *Shuck-fall spray.* Self-boiled lime-sulfur 8-8-50, dry-mixed sulfur lime, Atomic Sulfur, etc., or use sulfur dust. As soon as husks are off to protect young fruit.

4. *Summer sprays.* Same materials as in 3. To protect developing fruit. Apply at any time when brown-rot danger is evident.

5. *Pre-harvest spray.* About a month before fruit will be ripe. Use same materials as in 3. The most important single application for all stone fruits.

Summer sanitation. Keep orchard clear as far as practicable from rotting fruit in trees or on the ground, to reduce sources of infection.

Fall sanitation. Where practicable, clean up the fallen rotted fruit to prevent the development of mummies in the soil which will later produce the spore-cup stage.

Caution. Sweet cherries sometimes sustain size reduction from bordeaux and self-boiled lime-sulfur, hence after the petal-fall spray, dusting or the use of Atomic Sulfur is suggested for cherries in place of the heavier sprays.

Directions for the preparation of sprays can be had upon request to the Oregon Agricultural Experiment Station at Corvallis. The proper preparation of sprays is important in getting the best results.

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* Commercial liquid lime-sulfur. If the dry form is used, employ 4 lbs. to 50 gals. of water.

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* Deceased, November, 1923.